# Geomicrobiology of Subglacial Lake Whillans

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**Introduction**: Complex hydrologic systems beneath the Antarctic Ice Sheet contain an estimated $10^6$ $km^3$ of water in saturated sediments, streams, and over 200 subglacial lakes[1]. The combined subglacial outflow from Antarctic aquatic environments is estimated to equal that of the Amazon River Basin[1]. Hydrologic systems beneath the ice are dynamic and connected and are thought to comprise one of the world's largest organic carbon reservoirs, the bulk of which is likely derived from microbial biomass and metabolic activity[1,2]. The persistence of liquid water combined with the availability of energy sources provide suitable conditions to sustain life.

**Hypothesis**: The subglacial environments associated with Subglacial Lake Whillans represents a metabolically dynamic ecosystem that biogeochemically modifies the habitat.

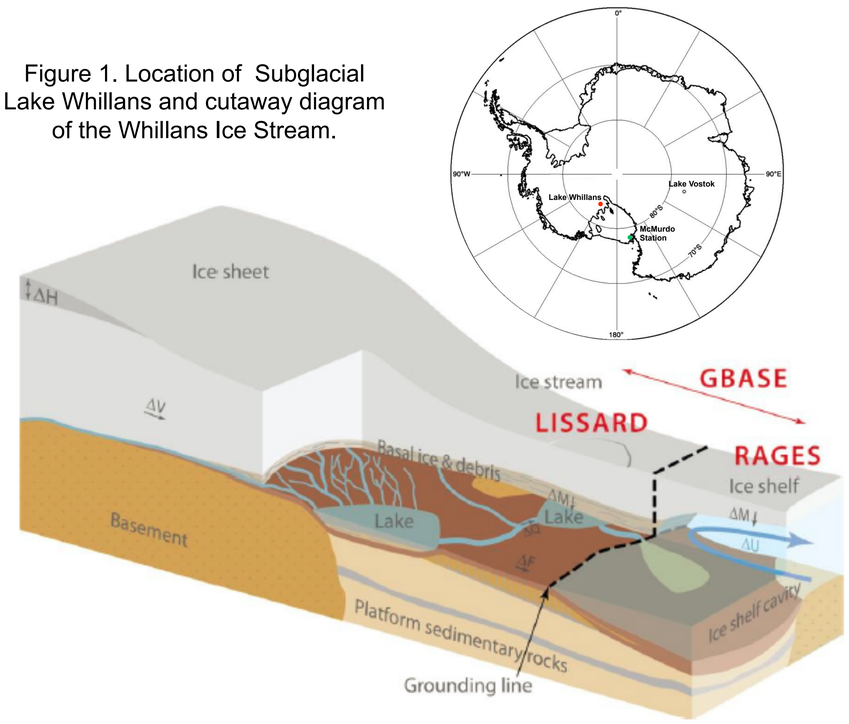


Figure 1. Location of Subglacial Lake Whillans and cutaway diagram of the Whillans Ice Stream.

**Project Overview**: The WISSARD (Whillans Ice Stream Subglacial Access Research and Drilling) project is an interdisciplinary effort that includes three components: (i) lake and ice stream subglacial access drilling (LISSARD); (ii) remote sampling of the subglacial cavity (RAGES); (iii) geomicrobiological studies of the Whillans subglacial environments (GBASE). Subglacial Lake Whillans (SLW) lies 800 m below the surface of the Whillans Ice Stream, has a maximum depth of ~15 m, and covers an area of ~60 km2. Whillans is an active subglacial lake, which fills over the course of approximately five years and drains episodically into the Ross Sea. SLW consists of distinct but connected sediment, water, and basal ice habitats. The primary goals of GBASE are to define the structure and function of subglacial microbial life and determine the role of this ecosystem to global processes. Specifically, the GBASE integrated sampling approach will describe microbial community structure, identify and measure metabolic processes, and understand biogeochemical cycling in all three SLW habitats.

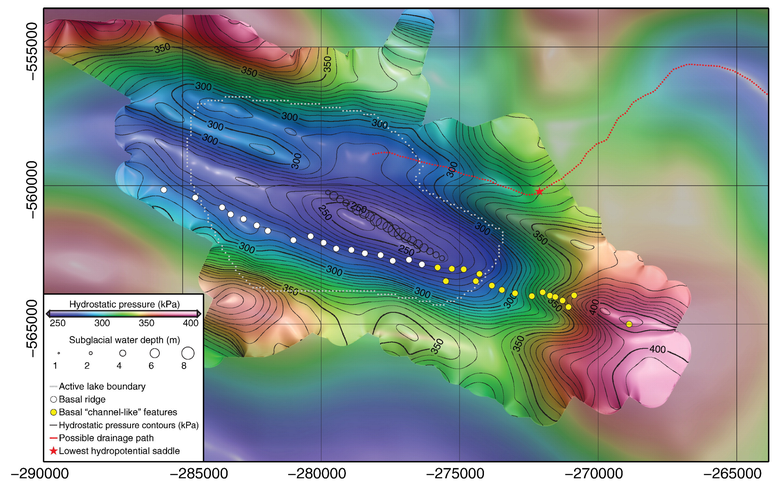


Figure 2. Hydropotential map of SLW and surrounding area, showing the active lake boundary (small white dots) and potential drainage path of water flowing from lake (small red dots) over the ridge of lowest hydropotential (red star)[3].

**Clean Access**: Environmental stewardship is a primary concern for the WISSARD project. To address this issue, WISSARD includes technologies to protect the environment, while at the same time, providing a high level of sample integrity.

The hot water drill is coupled to a custom filtration system designed to (i) remove particles (biotic and abiotic), (ii) irradiate the borehole water with ultraviolet (UV) radiation, and (iii) pasteurize the water to reduce microbial contamination. In addition, WISSARD clean access protocols include methods to clean the surfaces of cables/hoses and down-borehole equipment using hydrogen peroxide spray, pure water rinse, and germicidal UV radiation.

SLW is an active subglacial lake with a relatively short (~10 yr) residence time, therefore any drilling or sampling of SLW will have only a minor and transitory impact on the lake and associated subglacial environment.

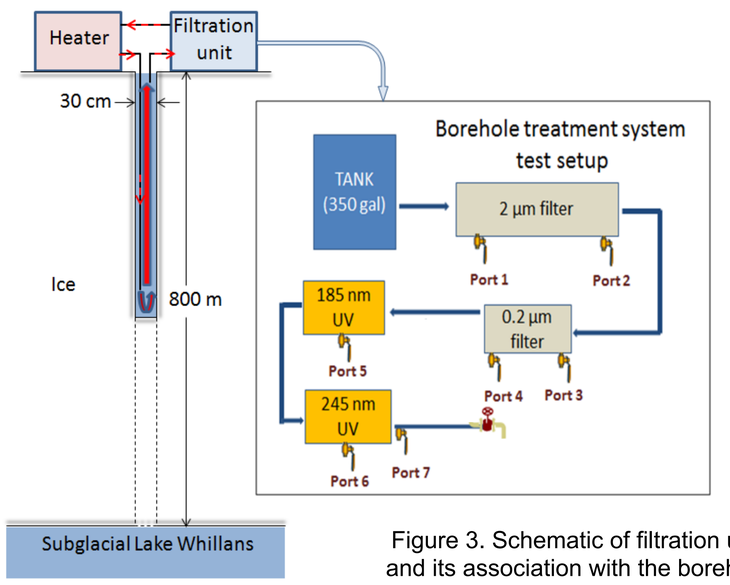


Figure 3. Schematic of filtration unit and its association with the borehole

**Methods**: Samples of basal ice, sediments, and liquid water will be collected and either evaluated on site, or returned to GBASE home institutions for analysis or archival.

### Discrete Samplers

- Enumeration of bacteria via epifluorescent microscopy
- Metabolic rate measurements using radiolabelled organic and inorganic substrates
- Water geochemistry
- Dissolved organic matter composition

A standard tool for sampling aquatic habitats, collects water from a specific depth.

### Basal Ice Corer

- Enumeration of sediment attached and free bacteria via epifluorescent microscopy
- 16S RNA based community analysis using DNA and reverse transcribed RNA
- Anaerobic and aerobic culturing

Uses clean, hot water drilling technology to core basal ice.

### Large volume *in situ* water sampler

- McLane Research Laboratories built an *in situ* water sampler designed to concentrate large volumes of water onto 142mm filters
- 16S RNA based community analysis using DNA and reverse transcribed RNA
- Anaerobic and aerobic culturing using sulfur and iron as energy sources

An *in situ* filter allows organisms to be collected while preserving expression of genes relevant to survival in SLW.

### Sediment Mutli-Corer

- Enumeration of bacteria via epifluorescent microscopy
- Metabolic rate measurements using radiolabelled organic and inorganic substrates
- Pore water geochemistry and dissolved gas analysis
- 16S RNA based community analysis using DNA and reverse transcribed RNA
- Microbial mineral weathering experiments

Triplicate cores of the surficial sediment at the bottom of SLW, preserving the important sediment-water interface.

**Implications**:

- Metabolically active subglacial microorganisms will modify the geochemistry of the subglacial environment by releasing nutrients bound to subglacial sediments and cycling organic matter. The end products of these microbial processes, as well as some of the cells themselves, can be released into the Southern Ocean as subglacial drainage and represent a missing link to our understanding of ocean biogeochemistry and the global carbon cycle.
- Subglacial environments are permanently cold and dark. They represent earthly analogues for other icy planetary bodies in our solar system. Sampling these unique habitats will increase our understanding of bacterial and metabolic diversity, while providing clues as to how life might persist in extra terrestrial environments.

References:
1. Priscu, J. et al. in Polar Lakes and Rivers. 320 (Oxford University Press, 2009).
2. Wadham, J. L. et al. (2012) *Nature.* 488:633-637.
3. Christianson et al. (2012) *Earth and Planetary Science Letters.* Vol 331-332.

**More information and regular updates posted at www.wissard.org**